T962 TPC Bias Voltage Filter Description

Original Rev. 13-JAN-2008

Current Rev. 25-JAN-2008

The TPC Bias Voltage Filters, which are external to the cryostat, serve at lease three important purposes:

- These filters break the ground loops caused by the cables that carry the Bias Voltage from the power supplies to the cryostat.
- They block noise on the Bias Voltage supplies from entering the cryostat.
- They provide over voltage protection so that an improper adjustment of the Bias Voltage supply will not result in break down of the TPC wire signal DC blocking capacitors which would both destroy the preamplifiers and may require opening the cryostat to replace damaged DC blocking capacitors.

The noise that is being blocked from entering the cryostat can come from either the Bias Voltage power supplies themselves, from other equipment that these supplies are connected to, or this noise could just be picked up from other sources by the relatively long SHV cables that connect the supplies to the cryostat (antenna effect).

Noise on the Bias Voltage leads must be blocked from entering the cryostat. Once any noise is allowed to enter the cryostat it is almost impossible to prevent it from interfering with the very small TPC wire signals.

Mounting and Grounding the Bias Voltage Filters

To be effective the Bias Voltage Filters must be mounted very close to the point where the Bias Voltage enters the cryostat. The top flange plate of the cryostat is the best object to define as the common ground point. Thus the Bias Voltage filters need to be mounted to bracket(s) that are welded to the top flange plate. The purpose of these bracket(s) is both to provide mechanical support for the filters and to provide the main ground connection to the filters. You absolutely can not use the shield on the SHV output cable from the filter to ground the filter.

Mechanical Construction of the Bias Voltage Filters

The Bias Voltage Filters need to be housed in metal box(es). It is fine to use either 3 separate boxes or one common box for all 3 TPC Bias Voltage Filters. I would not mount the filters for other supply Voltages in the same box with the TPC Bias Voltage Filters, e.g. the Purity Monitor should have its own separate filters.

You could use either die-cast aluminum boxes or NEMA steel boxes to hold the filters. These are available from manufacturers like Bud and Hammond through distributors like Newark. In either case, where ground connections are made to these boxes, it is important to first prepare a clean metal surface, to use external tooth lock washers on both sides of the metal surface, and to use big enough steel hardware to make a solid stable connection to the box. Number 10 steel hardware is convenient to use and it mechanically strong enough to make a good connection.

The SHV connector at the input to the filter must be isolated from the metal box that holds the filter. This is most easily done by mounting the SHV connector to a sheet of G10 a few inches on a side and thick enough (1/8" is fine) to give good mechanical support. This sheet of G10 is mounted to the wall of the box with screws. The hole in the metal box that the SHV connector passes through should provide about 1/10 inch of clearance around the shell of the SHV connector. You can look at the Bias Voltage input to the electronics box on the PAB cryostat to see an example of this construction. Do not mount the SHV connector directly in the wall of the metal box using mica or nylon washers or something like that. That type of construction would prevent making a solid connection to the shell of the SHV connector and it has other problems.

Note that the SHV output connector will most likely also need to be mounted in this way which isolates it from the metal filter box.

Filter Component Selection

This section presents the reasons for selecting the various component values used in the Bias Voltage Filters. Before that there are some general comments about the type of components used in the filters. For the reference designators please see the schematic drawing of the Bias Voltage Filter in this web directory.

- Resistors All of the resistors are wire wound and may appear to be over size for used in this filter application. The reasons

to use this type of resistor are:

- minimize the chance of an open resistor We do not want any of the resistors to open under a fault conditions. An open resistor in one of the resistors that break the ground loops could cause a safety problem. An open resistor in the "high voltage" line could leave the capacitors charged at 500 V when the power supply is turned off - also a safety problem.

- minimize the chance that any of the resistors that are in the "high voltage" lines will flash over under any conditions

- minimize the excess Johnson noise generated by the resistors in the filter

- Capacitors The capacitors used in the Bias Voltage filters should have a working voltage rating that provides a generous safety margin. These capacitors should use a good dielectric that does not make noise when it is polarized or have a failure mechanism. The capacitors must have a small effective series resistance up into the MHz range.

R1 The purpose of this resistor is to give the varistor something to work against when the power supply voltage is set too high and under normal conditions it provides part of the series resistance for the one pole RC filter. If the power supply voltage is set too high then the varistor (VR1) will start to conduct and cause current to flow through R1 and thus a voltage drop will appear across R1. This resistor must have enough resistance so that a nominal amount of conduction by VR1 will cause a voltage drop across it but have a small enough resistance so that the normal TPC detector current will cause almost no voltage drop across it. 20k Ohms is a good compromise value. Digi-Key No: RSB-20KCT-ND This is a 20k Ohm 3 Watt wire wound resistor about $1.56 each.

R2, R4, & R5 These resistors are used to break the ground loops.

They must have enough resistance so that any induced ground loop potential will appear across the resistor (and thus not induce a significant ground loop current) and they must have a small enough resistance so that the shields of the SHV cables always remain near ground potential even under fault conditions (e.g. a short from the center conductor to the shield in the SHV cable from the power supply). 200 Ohms is a good compromise value. Digi-Key No: RSB-200CT-ND This is a 200 Ohm 3 Watt wire wound resistor about 90 cents each.

R3 This is the main part of the R in the RC filter. It must be big enough to give the RC filter a long time constant (using a practical value of C) and it must be small enough so that there is very little voltage drop across it when a nominal value of current is drawn by the TPC detector wires. 50k Ohms is a good compromise. Digi-Key No: RSC-50KRCT-ND This is a 50k Ohm 5 Watt wire wound resistor about $1.69 each.

R6 This is a bleeder resistor to discharge the energy stored in the filter capacitors C1 & C2 when the Bias Voltage Filter is not in use, e.g. after the wire plane bias voltage supplies have been turned off. The value of this resistor must be big enough so that it draws very little current during normal operation yet small enough so that it can discharge the filter capacitors in finite time. A value of 100 Meg Ohms is OK. Note that it will take this resistor some minutes to discharge the filter capacitors. An Ohmite type Slim-Mox 104 resistor will work well in this application.

C1 & C2 These capacitors are the C in the RC filter.

They must be big enough to get an RC time constant many times longer than one over 60 Hz. They must have a working voltage at least two times the normal operating voltage. Polypropylene film dielectric is used to prevent excess noise when the capacitor is polarized. Two of these 0.47 uFd are shown in the schematic but using 4 of them would be of some advantage if there is room for them in the box that is selected to hold the filters. The ground side of these capacitors must have a solid low resistance low inductance connection to the metal box that holds the filter and thus to the mounting bracket that provides the main ground connection to the filter. Illinois Capacitor PPB series 0.47 uFd 1000 Volt Newark stock number: 30K6751 about $4.36 each.

VR1 This varistor provides the over voltage protection.

The voltage rating of this varistor should be just comfortably above the highest voltage that we may want to apply to the TPC wires. Note that the turn on of the varistor is not an absolutely square corner so that you must have some margin between the rated voltage of the varistor and the maximum TPC Wire Bias Voltage that you want to use. A 600 V DC varistor would be a good pick. Digi-Key No: P7258-ND The price of this part is about 50 cents each.

Notes:

- With two 0.47 uFd capacitors the time constant of this one pole RC filter is about 70k Ohm x 0.94 uFd = 66 msec or about 4 times period of the power line frequency.

- There is a separate R1 and R3 because you do not want the varistor right up against the C in the RC filter because you want the filter to be effective against any noise made by the varistor when it is operating close to its breakdown voltage. R1 is made big enough for the varistor to work against when the power supply is set too high. The bulk of the R in the RC filter is put down stream of the varistor, i.e. R3, so that the filter can be effective against any noise from the varistor.

- Unless the SHV cable run from the output of the filter to the Bias Voltage Feedthrough can be made very short and with minimum loop area then resistors R4 and R5 should be included and the filter's SHV output connector should be insulated from the metal filter box in the same way that the SHV input connector must be mounted.

Answers to Questions:

> could I just use a single capacitor ...

Although capacitors are available in larger sizes (in the 1000V rating the Illinois Capacitor PPB series is available up to the 0.68 uFd size) there are advantages in using multiple smaller capacitors in parallel.

The ultimate attenuation that the filter achieves in its "stop band" will be limited by the physical layout of the filter and by the parasitic characteristics of the component used in the filter. A realistic model of a capacitor includes a parasitic series resistance. By using multiple smaller capacitors in parallel you reduce the ill effect that this series resistance has on the final attenuation that the filter will achieve.

You can easily see this technique used even in consumer grade equipment. Next time you are looking at a pc mother board look at the banks of capacitors (both aluminum electrolytic and ceramic) that are used in parallel to make the power supply output for the cpu stiff enough.

Another important reason to use multiple capacitors in parallel is so that you can have multiple ground runs and connections to the metal box that holds the filter. Any voltage drop across these ground runs (due either to resistance or inductance in these connections) will appear as noise at the output of the filter. Using multiple runs in parallel will reduce this problem and increase the ultimate attenuation that the filter will achieve.

It is also because any noise that appears on the filter's ground connection will also appear on the filter's output that you need to have a solid ground connection to these filters. Their ground must exactly matches the ground that the preamps see. That is why the filters must be mounted to brackets that are welded to the flange plate of the cryostat. The filter can not do any better than the ground that it has.

These polypropylene dielectric capacitors were selected for the filters because: they have a low parasitic series self inductance and resistance (all of the "plates" in one of these capacitors are in parallel) and because the polypropylene film does not make excess noise with it is polarized. Other types of capacitors are not as good in these respects.

> (more capacitors) in parallel to C1 and C2 ...

There are two ways to think about this:

You could just double the number of capacitors and put them all in parallel (all with their own private ground connection to the metal box that holds the filter). That would increase the RC time constant and thus increase the attenuation of the filter in its "stop band", i.e. in this case the stop band is all frequencies above 1 over 2 pi R C.

The other solution would be to add a 2nd stage to the filter, i.e. put in another 20k or 50k Ohm series resistor and put the second pair of capacitors after it.

- You can calculate which of these options will give you more attenuation. Pick some frequency where there is likely to be a lot of noise (e.g. 720 Hz from the TransRex power supply making thousands of Amps for the Muon magnet or 50 kHz from the various switching power supplies around the T962 detector) and calculate the attenuation at that frequency for each option.

- The physical layout of the two stage option will have less parasitic coupling from its input to its output (because they are further apart in the two stage option and because the

parasitic capacitance of the two series resistors will be in series and thus couple less noise directly from the input to the output).

- If we needed to carefully filter out noise up into the region of 10's or 100's of MHz then we absolutely would need a second stage built with components that work will in that frequency range. E.G. if this filter was for use with the Atlas LAr Calorimeter or something like that which has high speed detector signals we would need a second stage build with physically smaller capacitors that can work well in that frequency range.

- The reason that we can consider another stage (with its additional series resistance) is because there is so little current flowing through this filter and thus even with 70k Ohms of series resistance there is little Voltage drop across it. Think how different the design of this filter would need to be if it had to supply 1 Amp of current. You could not stand a 70 KVolt drop across the filter. See the discussion about R3 above. To really design this we need to know:

  How much current will be flowing through this filter ?
  How much ionization current is there in the TPC detector ?
  How much parasitic leakage current flows in the rest of the Bias Voltage wiring after the filter ?
  How much Voltage drop across the filter is OK ?
  How stiff does the output from this filter need to be ?

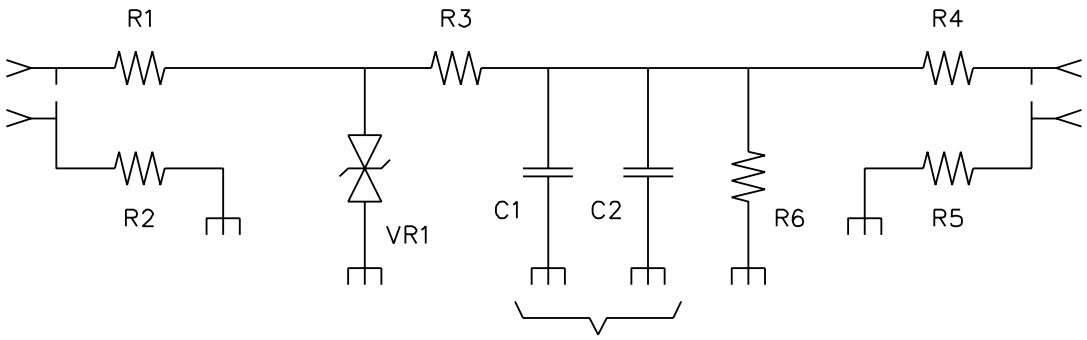
> ... putting together the HV filters for ArgoNeuT ...

It is a small point but it is better if you call these the Bias Voltage filters. The HV in the LArTPC detector system is the potential applied to the TPC cathode. There is typically a different filter for the cathode HV.

T962 Wire Bias Voltage Input Filter

Wire Bias Voltage from the Supply Filter Input Insulated SHV Connector

Wire Bias Voltage to the Cryostat Filter Output Insulated SHV Connector (see note below)



Good Ground Connection to the Filter Box and through the Filter Mounting Bracket to the Cryostat.

R1 20k Ohm	R6 100 Meg. Ohm
R2, R4, R5 200 Ohm	C1, C2 0.47 uFd 1000V
R3 50k Ohm	Varistor 600V

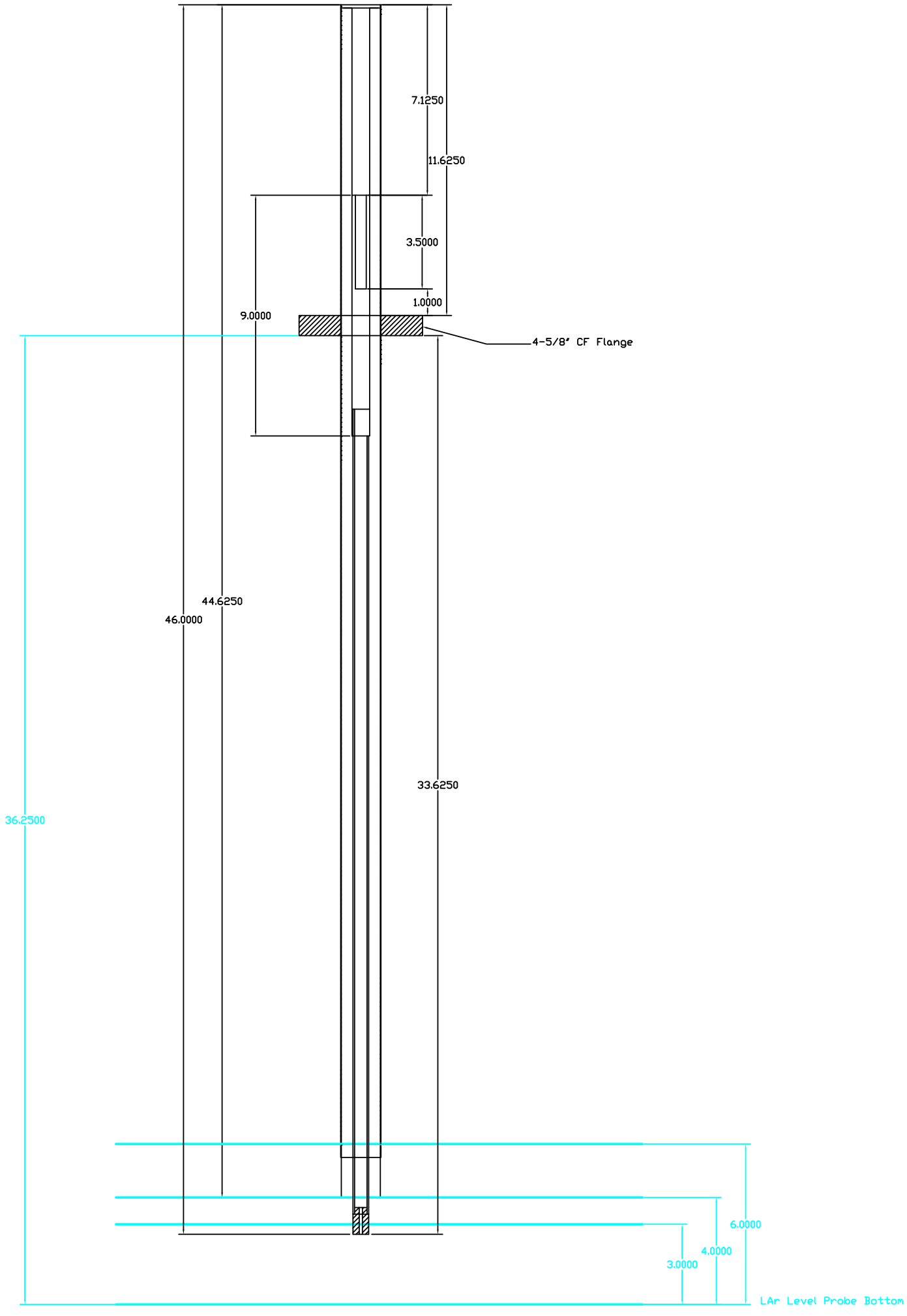
Each Bias Voltage Input Filter needs to be attached to a bracket that is welded onto the cryostat flange plate. This mounting is both for the mechanical support of the filter and to provide the main ground connection to the filter.

If the SHV cable run from the Output of the Bias Voltage Filter to the Bias Voltage Feedthrough is very short (small loop area) then R4 and R5 could be eliminated and the filter's SHV output connector could be mounted directy on the metal box that holds the filter.

If there is room in the box for a C3 and C4 it may be useful to double the amount of capacitance in the filter.

All ground symbols in this drawing are to a copper plate in the filter box that is well connected to the mounting bracket that both supports and grounds the filter.

Rev. 13-JAN-2008


7.1250
11.6250
3.5000
1.0000
9.0000
4-5/8" CF Flange
44.6250
46.0000
33.6250
36.2500
6.0000
4.0000
3.0000
LAr Level Probe Bottom

High Voltage for Long Bo

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October 2012

Contents

1 Purpose

Long Bo will use a liquid argon (LAr) time-projection chamber (TPC) as a detector to study neutrino interactions. The TPC applies an electric field to drift electrons produced in ionization of Ar atoms. For Long Bo's drift distance of $\sim$ 2.0 m, a 100 kV voltage is planned. To provide this voltage, a high voltage (HV) power supply has been ordered and an HV feedthrough (FT) will connect the cathode connection to the high-voltage line outside of the cryostat (LAPD).

The HV FT has already undergone testing successfully at lab six ramping up from 0-120 kV and holding 120 kV for periods up to an hour. This document desribes the HV system that will be used for Long Bo.

2 Description of the HV Setup

The HV system for Long Bo involves:

- an HV supply (Glassman LX150N12)
- two HV cables
- an HV feedthrough with Diala oil
- a bean (filter) pot

A sample setup is shown in Figure 1. These items will be described in the following sections.

Pictures of the location at PC4 can been seen in Figures 2a and 2b.

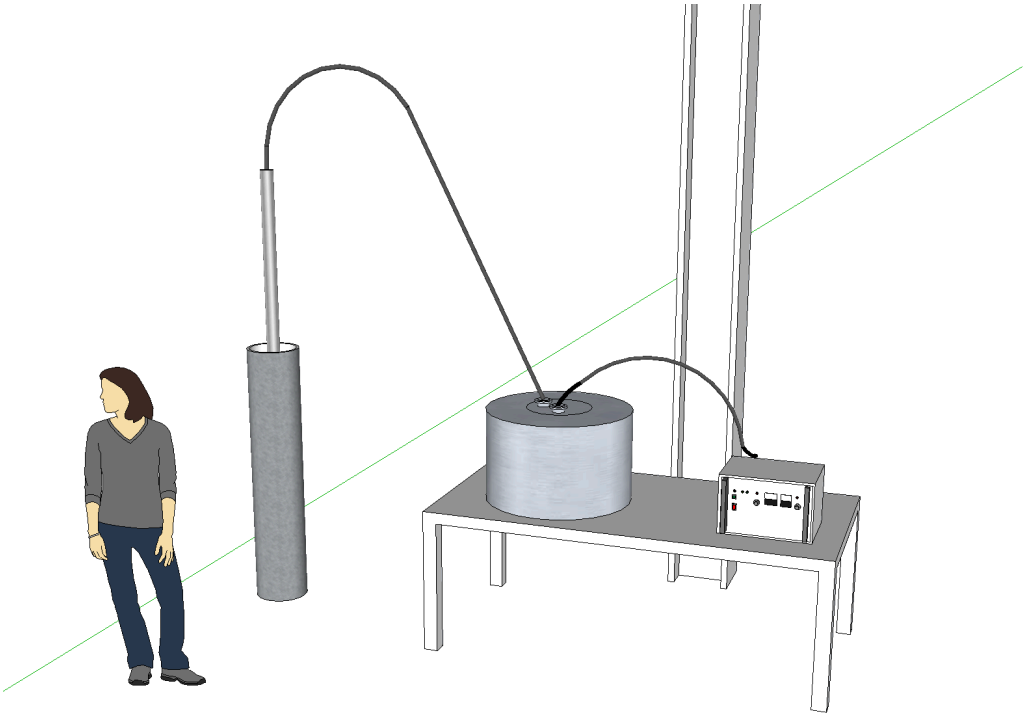
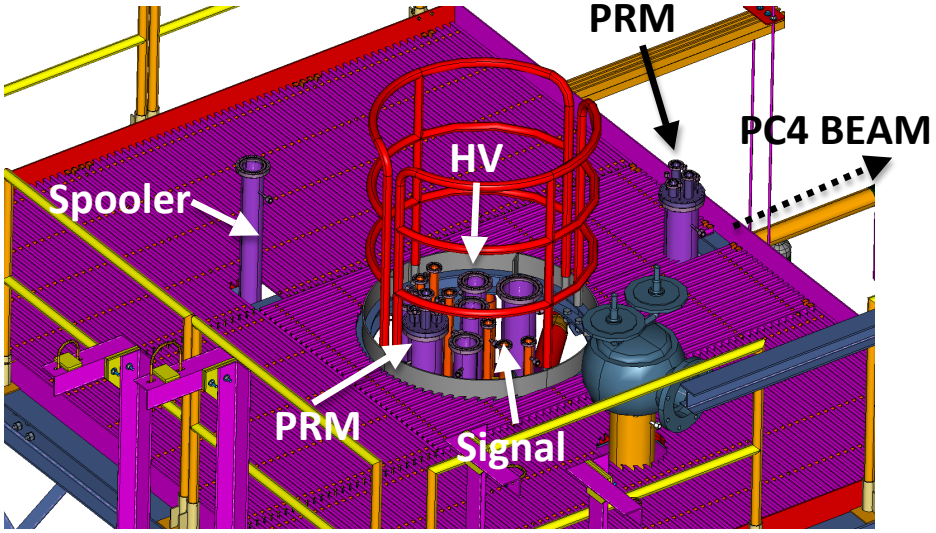
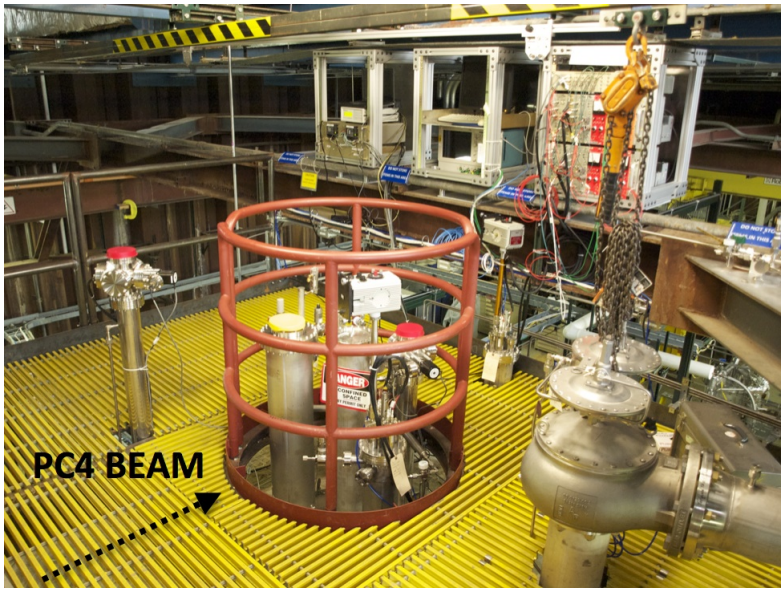


Figure 1: A sample setup showing the a proposed bean (filter) pot in connection to the HV supply and the HV cable leading to the cryostat.



(a)



(b)

Figure 2: Platform on top of LAPD. The bean (filter) pot and HV feedthrough will be here for Long Bo operation. The pot and secondary containment will sit on the grating.

2.1 Feedthrough

The HV FT is modeled after the FT used in the ICARUS experiment. A drawing is shown in Figure 4 and a photo is shown in Figure 3. This FT has been successfully tested at Lab 6 up to 150 kV for periods up to an hour.

Figure 3: Picture of the Long Bo HV feedthrough without cups.

The HV conductor on the FT is a 0.875" diameter pipe of stainless steel. The HV cable goes into the top of the FT and is fastened into contact with the pipe by the standard FT connection. The bottom of the FT connects to the TPC within the LAr by a spring-loaded tip coming in contact with a cup connected to the cathode plane. The midsection of the pipe is surrounded by UHMW PE for insulation. Grooves have been added to the lower section of the PE to reduce surface currents that could otherwise lead to electrical discharges. Radially beyond the PE surface is a tube of conducting stainless steel that will be connected to the flange of the cryostat by bellows that will allow the FT to be connected to the TPC. Within the LAr, further electric field shielding cups are attached to the inner conducting pipe and outer conducting ground providing added electrical discharge prevention. The FT with the attached cups is shown in Figure 5.

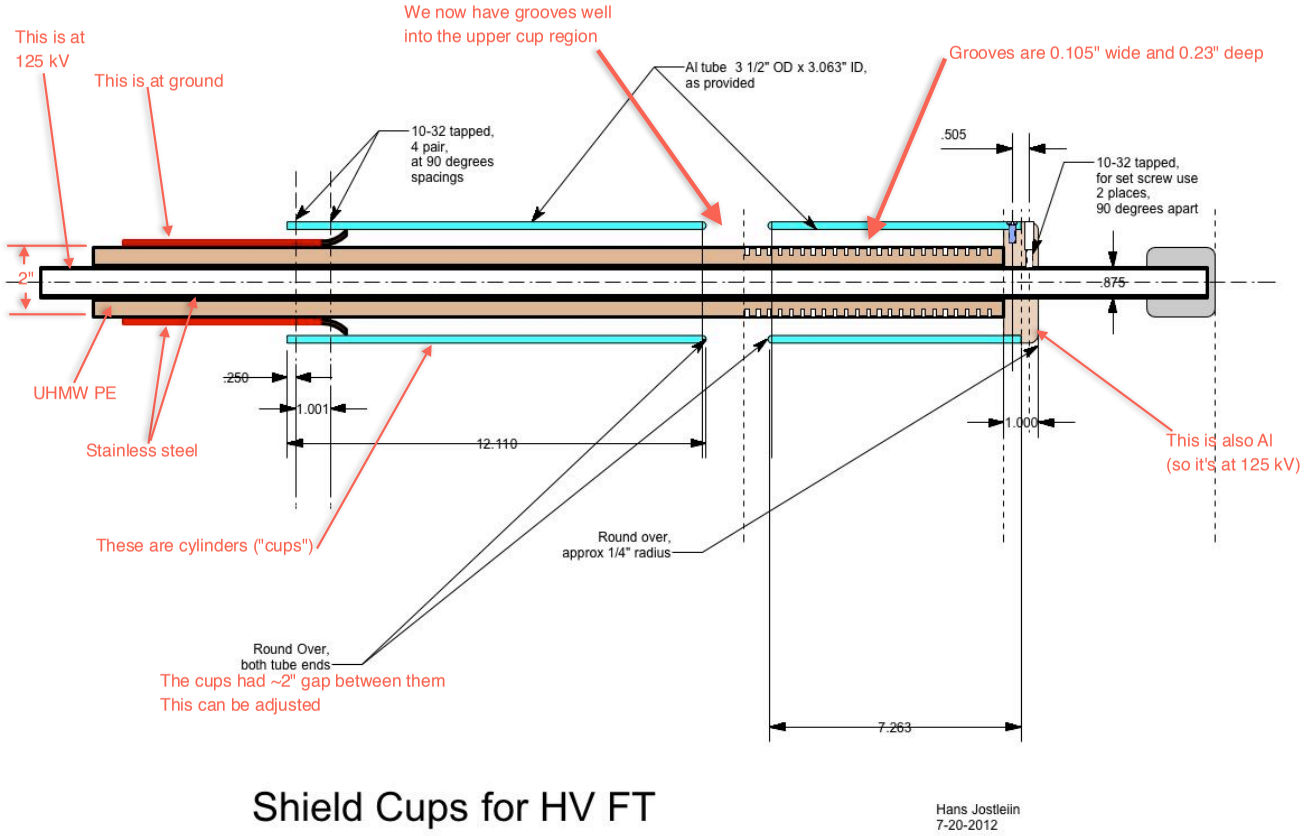


Figure 4: Annotated drawing of the ICARUS-style HV feedthrough.

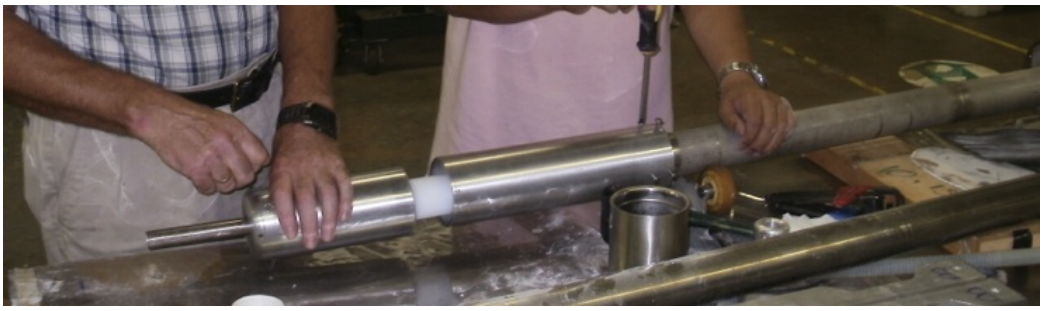


Figure 5: Picture of the lower section of an HV feedthrough with the shielding cups being attached.

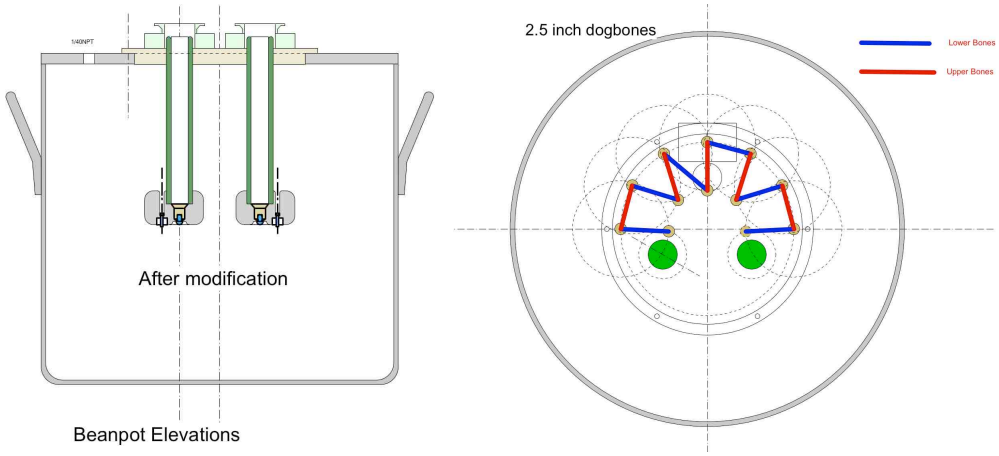
2.2 Bean Pot

Between the HV PS and the FT, we will put a bean (filter) pot. The purpose of the pot is twofold. Its first purpose is to filter the ripple current from the power supply. The second purpose is to absorb energy from a short, preventing damage to a TPC.

The bean pot consists of a pot, a flange, resistors, dog bone connectors (for the resistors), and Diala oil. The pot was made for a Tevatron voltage block (two high voltage out lines from one in). It was made by the Lincoln corporation and has Al walls and a welded top with an opening that allows for a flange with screws and an O-ring seal. It is 20" in diameter, 18.5" tall, and $\sim \frac{3}{16}$" thick. The flange has receptacles that accept our HV cables (see Figure 6a). The receptacles are made of G10 with Al where the where the cable conductive center meets. Within the pot, the receptacles are connected to eight 10 M resistors (made by TRW) (see Figure 7) connected in series via the dog bones (see Figures 6b and 8a). The dog bones are made from machined brass and special effort has been made to round all surfaces to reduce electric fields.

The entire assembly within the pot is submerged in Diala oil (see Section 2.3.3) to suppress any corona or discharges.

Nitrogen will be sent through the connection sockets and pot itself (see Figure 8b) during operation to ensure the oil does not come in contact with water in the air. The connections can be seen on the welded pot cover and the side of the flanges for the sockets.



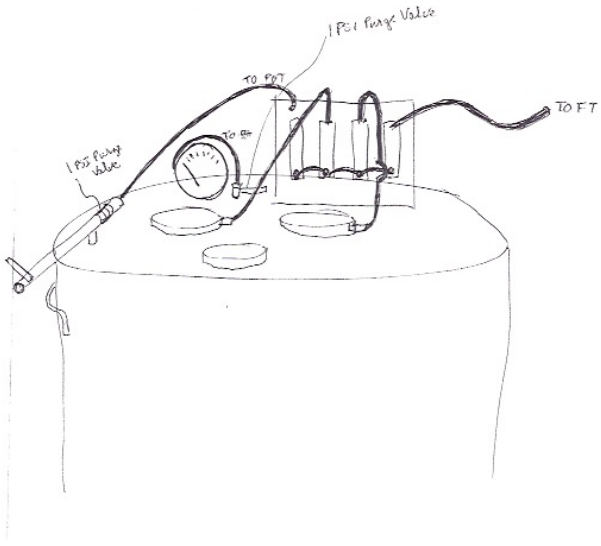
(a) (b)

Figure 6: Schematic drawings of the bean pot. Figure 6a highlights the cable receptacles, while Figure 6b shows the arrangement of the dog bones.

Figure 7: This is one of the resistors to be used in the bean pot.

(a)

(b)



(c)

Figure 8: Photos of the bean pot. Figure 8a shows how the resistors are connected to the top flange. Figure 8b shows the two pots with gas lines going into the pot. Figure 8c is a sketch further detailing the nitrogen gas connections.

2.3 Commercial Items

2.3.1 HV Supply

We will be using the Glassman LX150N12 model at 100 kV (unit is capable of 150 kV maximum; maximum of 1000 W output). We have also ordered a microcontroller interface from Glassman (option GE9) to monitor and control the HV during operation. The product reference sheets for both products are included in the Appendix.

2.3.2 Cable

The cable we will use to connect the HV FT to the bean pot is made from a Dielectric Sciences cable (type 2134). This same type of cable was used in previous Tevatron applications, and this cable was used in the successful tests at Lab 6. A technical drawing including characteristic values of the cable is shown in Figure 9.

The cable that will connect the power supply to the bean pot is supplied by Glassman and is type DS 2121.

2.3.3 Diala Oil

Diala oil is used to fill any air gaps within the FT near the connection to the HV cable and to fill the bean pot. Diala oil is an inert, common transformer oil that does not contaminate (poison) LAr. Injecting it in to displace any air gaps inhibits electrical breakdown on the cable within the FT. Within the bean pot, Diala oil provides a safe medium in which to place the resistive circuit. A copy of the Technical Data Sheet from the Shell Oil Corporation as well as the MSDS are included in Appendices B and C respectively. Nitrogen gas will be flowed through the connection of the cable to the feedthrough to ensure the Diala oil does not absorb water from the air.

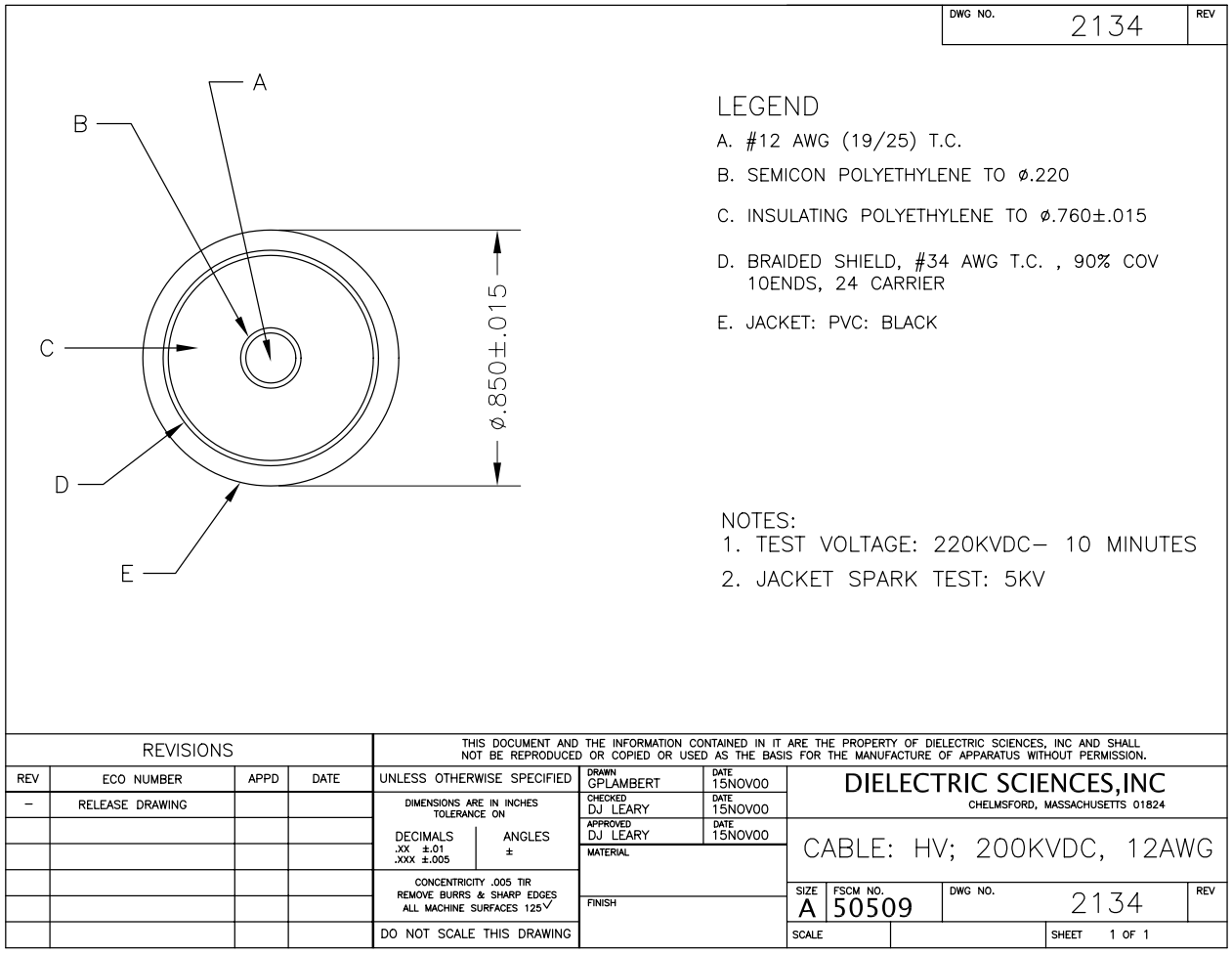


Figure 9: Drafting drawing of cross section of the Dielectric Sciences cable we use between the bean (filter) pot and the feed through.

3 Procedure to Operate High Voltage

1. Check the ground connections visually
2. Check that the HV power supply is dial set to zero by checking the knob
3. Turn on the HV power supply (remote enable and current trip mode selected)
4. Raise the HV to 70 kV (about two minutes)
5. Continue to raise the HV in steps of 5 kV every three minutes until 100 kV is reached
6. Turn on any monitoring programs

3.1 Grounding

We will connect all conducting ground surfaces to building ground. This includes the outside of the cryostat, the outer cylinder of the FT, the outer surface of the bean (filter) pot, and the ground stud of the HV supply.

A Glassman Product Reference Sheets

LX Series Extended Current* 1000 Watt Regulated High Voltage DC Power Supplies

Up To 150kV... 8.75 Inch Panel Height

Laboratory Performance

Enhanced Features

Fully compliant with the European harmonized EMI directive, EN50082-2, and with the low voltage (safety) directive, 73/23/EEC.

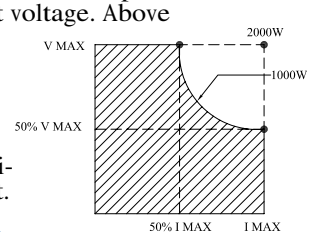
Check the specs... and compare

Models from 0 to 1kV through 0 to 150kV

The LX Series are 1000 watt regulated high voltage DC power supplies with an important difference ... maximum current ratings are equivalent to a 2000W supply! This maximum current, which is available for all output voltages up to 50% of rated voltage, should be of significant interest for many applications. The LX is offered with dual analog voltage and current meters or, optionally, with dual digital meters, or a blank panel for OEM/systems applications.

Features:

*Extended Current. LX models have maximum current ratings that are equivalent to a 2000W supply. These currents are available up to 50% of rated output voltage. Above this point, current is derated to maintain a constant 1000 W maximum output.



Pulse-Width Modulation. Off-the-line pulse-width modulation provides high efficiency and a reduced parts count for improved reliability.

Air Insulated. The LX Series features "air" as the primary dielectric medium. No oil or encapsulation is used to impede serviceability or increase weight.

Constant Voltage/Constant Current Operation. Automatic crossover from constant-voltage to constant-current regulation provides protection against overloads, arcs, and short circuits.

Low Ripple. Ripple is less than 0.03% of rated voltage at full load.

Tight Regulation. Voltage regulation is better than 0.005% for allowable line and load variations. Current regulation is better than 0.05% from short circuit to rated voltage.

Front Panel Controls (Analog and Digital Versions.) Separate 10-turn controls with locking vernier dials are used to set voltage and current levels. A high voltage enable switch and an AC power on/off switch complete the panel controls. L.E.D.'s indicate when high voltage is on, the output polarity, and whether the supply is operating in a voltage or current regulating mode. For the blank panel version, only a power on/off switch is provided on the panel.

Small Size and Weight. LX Series power supplies occupy only 8.75 inches of panel height. Net weight is less than 47 pounds.

Warranty. Standard power supplies are warranted for three years; OEM and modified power supplies are warranted for one year. A formal warranty statement is available.

Designing Solutions for High Voltage Power Supply Applications

GLASSMAN HIGH VOLTAGE INC.

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Printed in the U.S.A. B 12/19/03

Specifications

(from 5 to 100% of rated voltage. All units operate down to zero output with very slight degradation of performance.)

Input: Input: 102-132V RMS, single-phase, 48-63Hz, <20 A. A 3-position terminal block with protective cover is provided.

Efficiency: Typically 85% at full load.

Output: Continuous, stable adjustment, from 0 to rated voltage or current by panel mounted 10-turn potentiometers with 0.05% resolution, or by external 0 to 10V signals is provided. Voltage accuracy is 0.5% of setting + 0.2% of rated. Repeatability is <0.1% of rated.

Stored Energy: 60kV: 15J; 125kV: 30J.

Voltage Regulation: Better than 0.005% for specified line variations and 0.005% + 1 mV/mA for load variations.

Ripple: <0.03% of rated voltage + 1V RMS at full load (0.1% for 150 kV).

Current Regulation: Better than 0.1% from short circuit to rated voltage at any load condition.

Voltage Monitor: 0 to +10V equivalent to 0 to rated voltage. Accuracy, 0.5% reading + 0.2% rated.

Current Monitor: 0 to +10V equivalent to 0 to rated current. Accuracy, 1% reading + 0.05% rated for single polarity, 1% reading + 0.1% rated for reversible polarity.

Stability: 0.01% per hour after 1/2 hour warmup, 0.05% per 8 hours.

Voltage Rise/Decay Time Constant: 50 ms typical to 60kV (400 ms for higher voltages) with a 30% resistive load using either HV on/off or remote programming control.

Temperature Coefficient: 0.01% per degree C.

Ambient Temperature: -20 to +40 degrees C, operating; -40 to +85 degrees C, storage.

Polarity: Available with either positive, negative, or reversible polarity with respect to chassis ground.

Protection: Automatic current regulation protects against all overloads, including arcs and shorts. Fuses, surge-limiting resistors, and low energy components provide ultimate protection.

Accessory: Detachable 8-foot HV cable. See models chart for cable type.

Remote Controls: Terminal block is provided for all remote functions, including common, +10V reference, interlock, voltage and current program/monitor, HV Enable/Disable, ground, and local control.

External Interlock: Open off, closed on. Normally latching except for blank panel version where it is non-latching.

HV Enable/Disable: 0-1.5V off, 2.5-15V on.

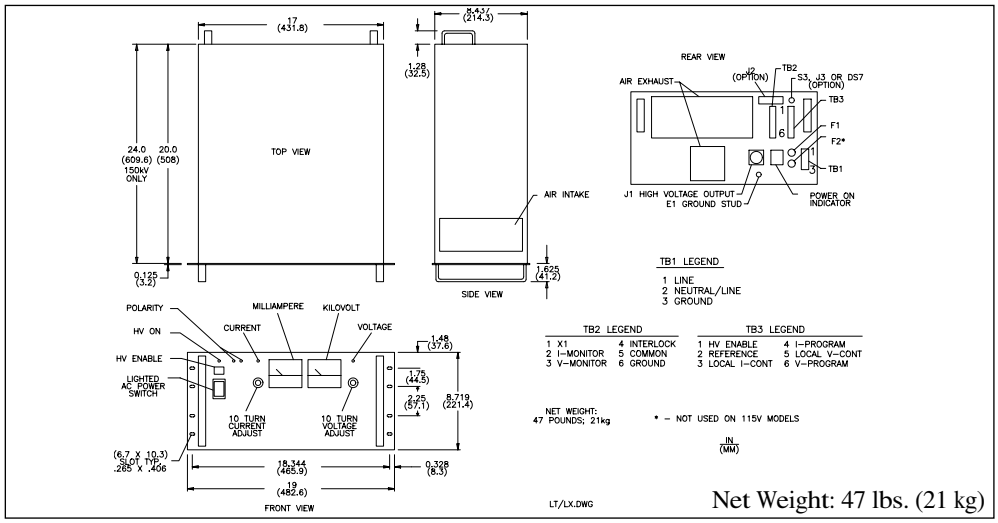
Options

Symbol	Description
100	100V ± 10% input, 48-63Hz. Derate currents by 20%, maximum 800W.
DM	3-1/2 digit LCD panel meters.
NC	Blank front panel, power switch only.
CT	Current trip. Power supply trips off when the load current reaches the programmed level. This option has a rear panel switch that selects either "trip" operation or current limiting.
ZR	Zero start interlock. Voltage control, local or remote, must be at zero before accepting an enable signal.
SS	Slow start ramp. Specify standard times of 1, 2, 3, 5, 10, 15, 20, or 30 s +/- 20%
5VC	0-5 V voltage and current program/monitor.

Models

Positive Polarity	Negative Polarity	Reversible Polarity	Output Voltage	Output Current	Output Cable	Panel Height
Reversible Polarity Only		LX1R2000	0-1kV	0-2000mA	RG-59	8.75 in.
		LX1.5R1300	0-1.5kV	0-1300mA	RG-59	8.75 in.
		LX2R1000	0-2kV	0-1000mA	RG-59	8.75 in.
		LX3R660	0-3kV	0-660mA	RG-59	8.75 in.
		LX5R400	0-5kV	0-400mA	RG-59	8.75 in.
		LX6R330	0-6kV	0-330mA	RG-58	8.75 in.
LX8P250	LX8N250	LX8R250	0-8kV	0-250mA	RG-8U	8.75 in.
LX10P200	LX10N200	LX10R200	0-10kV	0-200mA	RG-8U	8.75 in.
LX12P165	LX12N165	LX12R165	0-12kV	0-165mA	RG-8U	8.75 in.
LX15P132	LX15N132	LX15R132	0-15kV	0-132mA	RG-8U	8.75 in.
LX20P100	LX20N100	LX20R100	0-20kV	0-100mA	RG-8U	8.75 in.
LX30P66	LX30N66	LX30R66	0-30kV	0-66mA	RG-8U	8.75 in.
LX40P50	LX40N50	LX40R50	0-40kV	0-50mA	RG-8U	8.75 in.
LX50P40	LX50N40	LX50R40	0-50kV	0-40mA	RG-8U	8.75 in.
LX60P33	LX60N33	LX60R33	0-60kV	0-33mA	RG-8U	8.75 in.
LX80P25	LX80N25	LX80R25	0-80kV	0-25mA	DS 2124	8.75 in.
LX100P20	LX100N20	LX100R20	0-100kV	0-20mA	DS 2124	8.75 in.
LX125P16	LX125N16	LX125R16	0-125kV	0-16mA	DS 2121	8.75 in.
LX150P12	LX150N12	LX150R12	0-150kV	0-12mA	DS 2121	8.75 in.

Note: Product of voltage and current automatically limited to 1000W maximum



Net Weight: 47 lbs. (21 kg)

Designing Solutions for High Voltage Power Supply Applications

GLASSMAN HIGH VOLTAGE INC.

124 West Main Street, PO Box 317, High Bridge, NJ 08829-0317
(908) 638-3800 • Fax (908) 638-3700 • www.glassmanhv.com

RS-232 and USB Intelligent Power Supply Serial Interface Option GE9

This microcontroller interface is offered as an option for Glassman High Voltage power supplies. Its purpose is to provide remote control capability of analog program signals, analog monitor signals, and digital control signals and monitors using standard RS-232 or USB interface computer control.

***Note**: This option must be ordered with the power supply. It cannot be added to an existing supply by the user. Contact your Glassman representative for factory upgrade availability.*

GE9 RS-232 and USB Intelligent Power Supply Serial Interface.

Features

Control Functions. Provides full computer control of all remote control functions normally provided on the user interface connector of the power supply (varies per model). Additional functions may also be available on a special order basis (consult factory).

Isolation. 2500 VRMS galvanic Isolation is provided between the host computer and the HVPS.

Communications. All communications between the host computer and the interface is by means of ASCII encoded character strings with error checking.

Since the data link between the computer and the Glassman HV Power Supply is fully dedicated and hard-wired (there are no intermediate devices such as modems), none of the RS-232C handshaking signals are required.

Conversion Resolution. 10 BIT A/D (readback) and 12 BIT D/A (program).

Commands. A complete list of controller commands and syntax is provided for user application development. No programming is required for communication with the Glassman control software provided.

Installation: Can be located up to 3 ft from the HVPS.

Control Software: Basic control software is provided to program, monitor and enable the power supply. The software is shipped pre-configured for the scale factors required for each supply.
A Pentium® class or faster PC is recommended with mouse, Windows® operating system and I/O port as follows:
Serial Port: 98, 2000 or XP.
USB port: 2000 or XP only.

Size: Only 5" L x 3" W x 1.3"H.

Construction: Control hardware is fully enclosed and shielded.

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 Printed in the U.S.A. 102002-146GE9-A, NR-1, 4/6/2007

Specifications

Input: Power is provided by the HVPS via the Power Supply Interface Connector.

Resolution: 0.1%, 10 bit A/D and 12 bit D/A. The accuracy of the HV output and monitors are determined by the HVPS specifications.

Protocol: RS-232C is used with single-ended transmission over relatively short lines. This standard defines the electrical characteristics for the interfacing of Data Terminal Equipment (DTE) and Data Communications Equipment (DCE). USB (Universal Serial Bus) is a cable bus that supports data exchange between a host and peripheral. A USB system is described by three definitional areas: USB interconnects, USB devices and a USB host.

The power supply Interface acts strictly as a slave device. It will not transmit any messages over the data link unless it is first queried by the host computer.

The data are conveyed using ASCII encoded character strings. Scale factors are applied to the analog data by the host computer. The instruction manual provides signal information and configuration details.

The functions that can be controlled and monitored are dependent upon the functions provided for each HVPS series.

Computer Interface connectors: Female 9 Pin "D" connector (RS-232 port). Instructions for wiring the mating connector for "null modem" operation are detailed in the instruction manual provided. USB "mini B" connector.

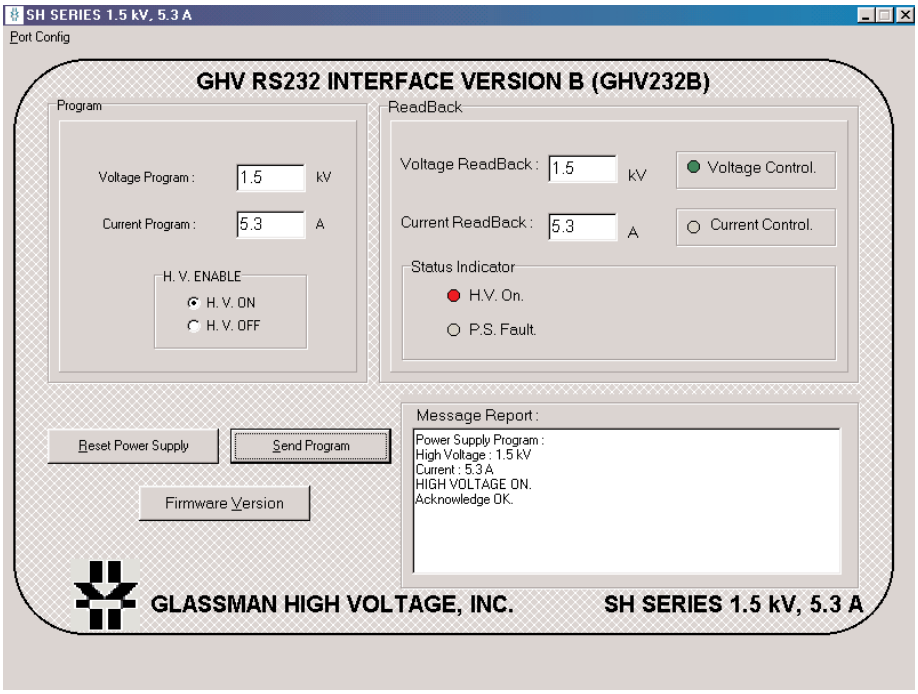
Power Supply Interface Connector: Female 25 Pin "D" connector. The signal connections vary as a function of the HVPS model.

Accessories: 3 foot shielded HVPS to controller interface cable including chassis return ground wire, 10 foot RS-232 "null modem" controller to host computer cable, 10 foot USB cable, Windows PC control software, USB serial port drivers, and Labview® drivers

Control Software: Software is provided on a CD ROM which allows the user to remotely operate the HVPS from a PC with MS Windows 98, 2000, or XP operating systems. The program consists of a main window and a pull down configuration menu. The main window allows programming and readback of the control signals, operation of the digital interface functions and reporting, and displays messages indicating the status of the HVPS and to report any errors.

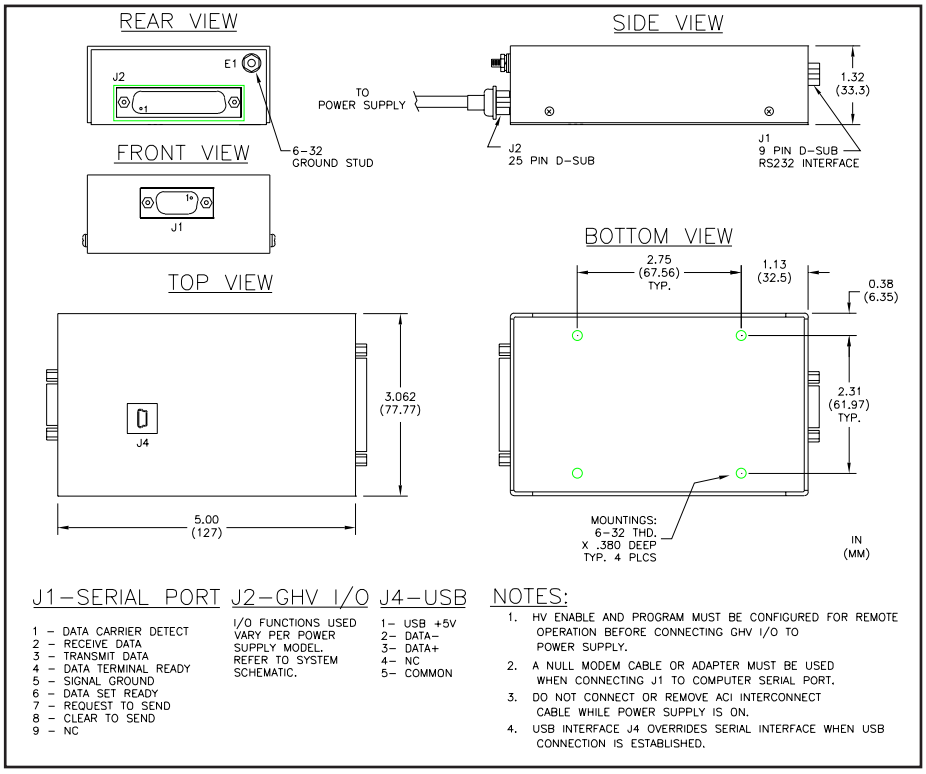
Please consult the factory for special requirements.

Program Screen



Typical program screen. (Indicators provided vary per model.)

Outline



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B Diala Oil Technical Data Sheets

Technical Data Sheet

Previous Name: **Shell Diala AX**

Shell **Diala *S2 ZX-A***

Inhibited electrical insulating oil

- ***RELIABLE PERFORMANCE***
- ***MEETS ASTM D3487 TYPE II***

Shell Diala S2 ZX-A is an inhibited electrical insulating oil manufactured from highly refined mineral oils. It offers good dielectric properties, good oxidation stability and provides efficient heat transfer even at low temperatures.

Shell Diala S2 ZX-A meets both the established and the new industry copper corrosion tests.

Applications

- ***Transformers***
  Electrical insulating oil for grid and industrial transformers.
- ***Electrical equipment***
  Components such as rectifiers, circuit breakers and switchgears.

Advice on applications not covered in this leaflet may be obtained from your Shell Representative.

Performance Features and Advantages

- ***Extended oil life***
  Shell Diala S2 ZX-A is an inhibited oil giving outstanding oxidation performance and an extended oil life.
- ***System efficiency***
  The good low temperature properties of the oil ensures proper heat transfer inside the transformer, even from low starting temperatures.
- ***Transformer protection***
  Shell Diala S2 ZX-A is non-corrosive towards copper, with no need for additional passivation. Shell Diala S2 ZX-A meets all relevant tests on copper corrosion ASTM D1275, and also the latest more severe tests: IEC 62535 and ASTM D1275B.

Specification and Approvals

Shell Diala S2 ZX-A meets the requirements of ANSI/ASTM D 3487 Type II

Storage precautions

The critical electrical properties of Shell Diala S2 ZX-A are easily compromised by trace contamination with foreign material. Typically encountered contaminants include moisture, particles, fibres and surfactants. Therefore, it is imperative that electrical insulating oils be kept clean and dry.
It is strongly recommended that storage containers be dedicated for electrical service and include airtight seals. It is further recommended that electrical insulating oils be stored indoors in climate-controlled environments.

Health and Safety

Guidance on Health and Safety is available on the appropriate Material Safety Data Sheet which can be obtained from your Shell representative.

Shell Diala S2 ZX-A is free from polychlorinated biphenyls (PCB).

Protect the environment

Take used oil to an authorized collection point. Do not discharge into drains, soil or water.

Typical Characteristics

Property	Units	Method	ASTM D 3487 Type II Requirement	Shell Diala S2 ZX-A
Kinematic viscosity at 0 °C	mm^2/s	ASTM D 445	max. 76	60
Kinematic viscosity at 40 °C	mm^2/s	ASTM D 445	max. 12	9
Kinematic viscosity at 100 °C	mm^2/s	ASTM D 445	max. 3	2.2
Flashpoint COC	°C	ASTM D 92	min. 145	150
Pourpoint	°C	ASTM D 97	max. -40	-57
Aniline point	°C	ASTM D 611	63-84	69
Appearance		ASTM D 1524	Clear & Bright	Clear & Bright
Density at 15 °C	kg/m^3	ASTM D 1298	max. 910	890
Interfacial tension @ 25 °C	mN/m	ASTM D 971	min. 40	42
Corrosive Sulphur		ASTM D 1275	Not corrosive	Not corrosive
Corrosive Sulphur		ASTM D 1275 B	Not corrosive	Not corrosive
Corrosive Sulphur		IEC 62535	Not corrosive	Not corrosive
Water content	mg/kg	ASTM D 1533	max. 35	<30
Oxidation Inhibitor content	%m	ASTM D 1473	max. 0.3	complies
Dielectric Breakdown Voltage		ASTM D 1816		
Oil as received	kV	ASTM D 1816 (VDE)	min. 35	40
After treatment	kV	ASTM D 1816 (VDE)	min. 56	>70
Dielectric Breakdown voltage Impulse	kV	ASTM D 3300	min. 145	>300
Dielectric Dissipation Factor (DDF) at 100 °C		ASTM D 924	max. 0.3	0.1
PCB content	mg/kg	ASTM D 4059	Not detectable	Not detectable
Oxidation Stability @ 72 hrs		ASTM D 2440		
Sludge	%m		max. 0.1	<0.01
Total acid number	mg KOH/g		max. 0.3	<0.01
Oxidation Stability @ 164 hrs		ASTM D 2440		
Sludge	%m		max. 0.2	0.01
Total acid number	mg KOH/g		max. 0.4	0.1
Oxidation Stability (RPVOT)	min	ASTM D 2112	min. 195	240
Gassing Tendency	mm^3/min	ASTM D 2300	max. 30	complies

These characteristics are typical of current production.
Whilst future production will conform to Shell's specification, variations in these characteristics may occur.

C Diala Oil MSDS

Material Safety Data Sheet

1. MATERIAL AND COMPANY IDENTIFICATION

Material Name : **Shell Diala S2 ZX-A**
Uses : Insulating oil.

Manufacturer/Supplier : **SOPUS Products**
PO BOX 4427
Houston, TX 77210-4427
USA
MSDS Request : 877-276-7285

Emergency Telephone Number
Spill Information : 877-242-7400
Health Information : 877-504-9351

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Identity	CAS No.	Concentration
Distillates (petroleum), hydrotreated light naphthenic	64742-53-6	60.00 - 100.00 %

Highly refined mineral oils and additives.
The highly refined mineral oil contains <3% (w/w) DMSO-extract, according to IP346.

3. HAZARDS IDENTIFICATION

Emergency Overview

Appearance and Odour : Clear. Liquid at room temperature. Slight hydrocarbon.

Health Hazards : Harmful: may cause lung damage if swallowed.
Safety Hazards : Not classified as flammable but will burn.
Environmental Hazards : Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Health Hazards
Inhalation : Under normal conditions of use, this is not expected to be a primary route of exposure.
Skin Contact : Prolonged or repeated skin contact without proper cleaning can clog the pores of the skin resulting in disorders such as oil acne/folliculitis.
Eye Contact : May cause slight irritation to eyes.
Ingestion : Harmful: may cause lung damage if swallowed.
Signs and Symptoms : If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever. The onset of respiratory symptoms may be delayed for several hours after exposure. Oil acne/folliculitis signs and symptoms may include formation of black pustules and spots on the skin of exposed areas. Ingestion may result in nausea, vomiting and/or

diarrhoea.

Aggravated Medical Conditions	:	Pre-existing medical conditions of the following organ(s) or organ system(s) may be aggravated by exposure to this material: Skin.
Additional Information	:	Under normal conditions of use or in a foreseeable emergency, this product meets the definition of a hazardous chemical when evaluated according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

4. FIRST AID MEASURES

Inhalation	:	No treatment necessary under normal conditions of use. If symptoms persist, obtain medical advice.
Skin Contact	:	Remove contaminated clothing. Flush exposed area with water and follow by washing with soap if available. If persistent irritation occurs, obtain medical attention.
Eye Contact	:	Flush eye with copious quantities of water. If persistent irritation occurs, obtain medical attention.
Ingestion	:	If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration. If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing.
Advice to Physician	:	Treat symptomatically. Potential for chemical pneumonitis. Consider: gastric lavage with protected airway, administration of activated charcoal. Call a doctor or poison control center for guidance.

5. FIRE FIGHTING MEASURES

Clear fire area of all non-emergency personnel.

Flash point	:	Typical 150 °C / 302 °F (COC)
Upper / lower Flammability or Explosion limits	:	Typical 1 - 10 %(V)(based on mineral oil)
Auto ignition temperature	:	> 320 °C / 608 °F
Specific Hazards	:	Hazardous combustion products may include: A complex mixture of airborne solid and liquid particulates and gases (smoke). Carbon monoxide. Unidentified organic and inorganic compounds.
Suitable Extinguishing Media	:	Foam, water spray or fog. Dry chemical powder, carbon dioxide, sand or earth may be used for small fires only.
Unsuitable Extinguishing Media	:	Do not use water in a jet.
Protective Equipment for Firefighters	:	Proper protective equipment including breathing apparatus must be worn when approaching a fire in a confined space.

6. ACCIDENTAL RELEASE MEASURES

Avoid contact with spilled or released material. For guidance on selection of personal protective equipment see Chapter 8 of this Material Safety Data Sheet. See Chapter 13 for information on disposal. Observe the relevant local and international regulations.

Protective measures : Avoid contact with skin and eyes. Use appropriate containment to avoid environmental contamination. Prevent from spreading or entering drains, ditches or rivers by using sand, earth, or other appropriate barriers.

Clean Up Methods : Slippery when spilt. Avoid accidents, clean up immediately. Prevent from spreading by making a barrier with sand, earth or other containment material. Reclaim liquid directly or in an absorbent. Soak up residue with an absorbent such as clay, sand or other suitable material and dispose of properly.

Additional Advice : Local authorities should be advised if significant spillages cannot be contained.

7. HANDLING AND STORAGE

General Precautions : Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols. Properly dispose of any contaminated rags or cleaning materials in order to prevent fires. Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for safe handling, storage and disposal of this material.

Handling : Avoid prolonged or repeated contact with skin. Avoid inhaling vapour and/or mists. When handling product in drums, safety footwear should be worn and proper handling equipment should be used.

Storage : Keep container tightly closed and in a cool, well-ventilated place. Use properly labelled and closeable containers. Storage Temperature: 0 - 50 °C / 32 - 122 °F

Recommended Materials : For containers or container linings, use mild steel or high density polyethylene.

Unsuitable Materials : PVC.

Additional Information : Polyethylene containers should not be exposed to high temperatures because of possible risk of distortion.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits

Material	Source	Type	ppm	mg/m3	Notation
Distillates (petroleum), hydrotreated light naphthenic	OSHA Z1	PEL	500 ppm	2,000 mg/m3	

Distillates (petroleum), hydrotreated light naphthenic	OSHA Z1A	TWA	400 ppm	1,600 mg/m3	
Distillates (petroleum), hydrotreated light naphthenic	ACGIH	TWA(Inhalable fraction.)		5 mg/m3	

Oil mist, mineral	ACGIH	TWA(Inhalable fraction.)		5 mg/m3	
Oil mist, mineral	OSHA Z1	PEL(Mist.)		5 mg/m3	
Oil mist, mineral	OSHA Z1A	TWA(Mist.)		5 mg/m3	
Oil mist, mineral	OSHA Z1	(Mist.)			Listed.

Additional Information : Shell has adopted as Interim Standards the OSHA Z1A values that were established in 1989 and later rescinded.

Exposure Controls : The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include: Adequate ventilation to control airborne concentrations. Where material is heated, sprayed or mist formed, there is greater potential for airborne concentrations to be generated.

Personal Protective Equipment : Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.

Respiratory Protection : No respiratory protection is ordinarily required under normal conditions of use. In accordance with good industrial hygiene practices, precautions should be taken to avoid breathing of material. If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation. Check with respiratory protective equipment suppliers. Where air-filtering respirators are suitable, select an appropriate combination of mask and filter. Select a filter suitable for combined particulate/organic gases and vapours [boiling point >65°C(149 °F)].

Hand Protection : Where hand contact with the product may occur the use of gloves approved to relevant standards (e.g. Europe: EN374, US: F739) made from the following materials may provide suitable chemical protection: PVC, neoprene or nitrile rubber

		gloves. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, glove thickness, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced. Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.
Eye Protection	:	Wear safety glasses or full face shield if splashes are likely to occur.
Protective Clothing	:	Skin protection is not required under normal conditions of use. It is good practice to wear chemical resistant gloves.
Monitoring Methods	:	Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate.
Environmental Exposure Controls	:	Minimise release to the environment. An environmental assessment must be made to ensure compliance with local environmental legislation.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Clear. Liquid at room temperature.
Odour	:	Slight hydrocarbon.
pH	:	Not applicable.
Initial Boiling Point and Boiling Range	:	> 280 °C / 536 °F estimated value(s)
Pour point	:	Typical -57 °C / -71 °F
Flash point	:	Typical 150 °C / 302 °F (COC)
Upper / lower Flammability or Explosion limits	:	Typical 1 - 10 %(V) (based on mineral oil)
Auto-ignition temperature	:	> 320 °C / 608 °F
Vapour pressure	:	< 0.5 Pa at 20 °C / 68 °F (estimated value(s))
Specific gravity	:	Typical 0.890 at 15 °C / 59 °F
Density	:	Typical 890 kg/m3 at 15 °C / 59 °F
Water solubility	:	Negligible.
n-octanol/water partition coefficient (log Pow)	:	> 6 (based on information on similar products)
Kinematic viscosity	:	Typical 9 mm2/s at 40 °C / 104 °F
Vapour density (air=1)	:	> 1 (estimated value(s))
Evaporation rate (nBuAc=1)	:	Data not available

10. STABILITY AND REACTIVITY

Stability	:	Stable.
Conditions to Avoid	:	Extremes of temperature and direct sunlight.
Materials to Avoid	:	Strong oxidising agents.
Hazardous Decomposition Products	:	Hazardous decomposition products are not expected to form during normal storage.

11. TOXICOLOGICAL INFORMATION

Basis for Assessment	:	Information given is based on data on the components and the toxicology of similar products.
Acute Oral Toxicity	:	Expected to be of low toxicity: LD50 > 5000 mg/kg , Rat Aspiration into the lungs may cause chemical pneumonitis which can be fatal.
Acute Dermal Toxicity	:	Expected to be of low toxicity: LD50 > 5000 mg/kg , Rabbit
Acute Inhalation Toxicity	:	Not considered to be an inhalation hazard under normal conditions of use.
Skin Irritation	:	Expected to be slightly irritating. Prolonged or repeated skin contact without proper cleaning can clog the pores of the skin resulting in disorders such as oil acne/folliculitis.
Eye Irritation	:	Expected to be slightly irritating.
Respiratory Irritation	:	Inhalation of vapours or mists may cause irritation.
Sensitisation	:	Not expected to be a skin sensitiser.
Repeated Dose Toxicity	:	Not expected to be a hazard.
Mutagenicity	:	Not considered a mutagenic hazard.
Carcinogenicity	:	Product contains mineral oils of types shown to be non-carcinogenic in animal skin-painting studies. Highly refined mineral oils are not classified as carcinogenic by the International Agency for Research on Cancer (IARC). Other components are not known to be associated with carcinogenic effects.
Reproductive and Developmental Toxicity	:	Not expected to be a hazard.
Additional Information	:	Used oils may contain harmful impurities that have accumulated during use. The concentration of such impurities will depend on use and they may present risks to health and the environment on disposal. ALL used oil should be handled with caution and skin contact avoided as far as possible.

12. ECOLOGICAL INFORMATION

Ecotoxicological data have not been determined specifically for this product. Information given is based on a knowledge of the components and the ecotoxicology of similar products.

Acute Toxicity	:	Poorly soluble mixture. May cause physical fouling of aquatic organisms. Expected to be harmful: LL/EL/IL50 10-100 mg/l (to aquatic organisms) (LL/EL50 expressed as the nominal amount of product required to prepare aqueous test extract).
Mobility	:	Liquid under most environmental conditions. Floats on water. If it enters soil, it will adsorb to soil particles and will not be mobile.
Persistence/degradability	:	Expected to be not readily biodegradable. Major constituents are expected to be inherently biodegradable, but the product contains components that may persist in the environment.
Bioaccumulation	:	Contains components with the potential to bioaccumulate.
Other Adverse Effects	:	Product is a mixture of non-volatile components, which are not

expected to be released to air in any significant quantities. Not expected to have ozone depletion potential, photochemical ozone creation potential or global warming potential.

13. DISPOSAL CONSIDERATIONS

Material Disposal	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses.
Container Disposal	:	Dispose in accordance with prevailing regulations, preferably to a recognised collector or contractor. The competence of the collector or contractor should be established beforehand.
Local Legislation	:	Disposal should be in accordance with applicable regional, national, and local laws and regulations.

14. TRANSPORT INFORMATION

US Department of Transportation Classification (49CFR)
This material is not subject to DOT regulations under 49 CFR Parts 171-180.

IMDG
This material is not classified as dangerous under IMDG regulations.

IATA (Country variations may apply)
This material is either not classified as dangerous under IATA regulations or needs to follow country specific requirements.

15. REGULATORY INFORMATION

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

Federal Regulatory Status

Notification Status

EINECS	All components listed or polymer exempt.
TSCA	All components listed.
DSL	All components listed.

Shell classifies this material as an "oil" under the CERCLA Petroleum Exclusion, therefore releases to the environment are not reportable under CERCLA.

State Regulatory Status

California Safe Drinking Water and Toxic Enforcement Act (Proposition 65)

This material does not contain any chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

New Jersey Right-To-Know Chemical List

Distillates (petroleum), hydrotreated light naphthenic (64742-53-6)	Listed.

Pennsylvania Right-To-Know Chemical List

Distillates (petroleum), hydrotreated light naphthenic (64742-53-6)	Listed.

16. OTHER INFORMATION

NFPA Rating (Health, Fire, Reactivity)	:	0, 1, 0
MSDS Version Number	:	1.2
MSDS Effective Date	:	09/07/2011
MSDS Revisions	:	A vertical bar (|) in the left margin indicates an amendment from the previous version.
MSDS Regulation	:	The content and format of this MSDS is in accordance with the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
MSDS Distribution	:	The information in this document should be made available to all who may handle the product.
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